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N release depending on soil and humus content

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ABSTRACT

Pot experiments with three different soil types and a wide range of total carbon and nitrogen content have been carried out since 1982 under open field and greenhouse conditions. After 10 years, N uptake shows great differences between experimental conditions, soil types and C levels. N uptake varies from 915 kg/ha to 2750 kg/ha. On an average of all soil types and C-levels the content of total carbon under open field conditions remained unchanged, while in greenhouse experiments the content decreased. Contrary to C content, the N content decreased in all treatments, mostly in the greenhouse. This fact caused an increase on C/N ratios.

1. INTRODUCTION

N release of soil depends on the content of organic matter (OM), characterized by total carbon and total nitrogen content. The amounts of nitrogen,which are linked in organic form in the soil, range from 2000 to more than 10000 kg/ha. However, for N release the total N content is not decisive, only the mineralisable part is. This part is mainly influenced by the management (crop rotation, fertilization) while the inert part of OM is mostly unconcerned with mineralisation and strongly correlated to the particle size distribution of soil. These relations were quantified and directories for soil organic matter (SOM) for the middle part of Germany were worked out (KÖRSCHENS u.a., 1986). Climatic and weather conditions play an important role for both fractions. In cool and wet regions (mountains) mineralisation is a strong retard and a great amount of OM has accumulated. In warm and moist regions the conditions for mineralisation are much more favourable and a lower amount of OM has accumulated. The " Effective Mineralisation Time (EMT)" is used as criterion of mineralisation intensity of one site . This corresponds to the incubation time under optimal conditions (KARTSCHALL, 1986).

The N release can amount from 50 to >250 kg/ha annually depending on soil content of mineralisable SOM and EMT, that can range to 100 % in extreme years on the same site.

2.MATERIAL AND METHODS

Since 1982 a pot experiment with three different soil types and a wide range of total C and N content have been carried out for evidence of these relations. The characterization of experimental sites, from which the used soil samples were taken, is

as follows:

site of experiment	Groß Kreutz	Lauchstädt	Lauterbach
soil type	loamy sand	loam	loam
FAO classification	Albic Luvisol	Haplic Chernozem	Dystic Cambisol
clay content (%)	3	23	15
elevation (m above sea level)	42	110	580
annual precipitation	537	490	900
mean temperature (°C)	8,9	8,6	6,3
duration of exp. (years)	13	77	15

One part of this experiment was carried out under open field conditions, only with water from precipitation. In very dry periods the plants got distilled water against dry up. The second part of the experiment was conducted in a greenhouse without heating. The soil was kept at 60 % water capacity by a water supply with distilled water. The experiment runs without N fertilization.

Following crops have been cultivated:

1982	1. corn, 2. brassica
1983	1. oats, 2. corn
1984	sugar beet
1985	corn
1986	sugar beet
1987	sugar beet
1988	corn
1989	1. oats, 2. brassica
1990	corn
1991	sugar beet

All investigations based on standard methods.

3. RESULTS

N uptake (Fig.1) shows great differences between experimental conditions, soil types and starting level of carbon content. In all cases under a greenhouse environment more N was used than under open field conditions. This was caused by much more favourable mineralisation conditions, due to the equal moisture and higher temperature. Accordingly the greater the differences the higher content on decomposable OM. The soil at the site Lauterbach , due to the low EMT, accumulated the highest amount of decomposable OM and in the pot experiment, under favourable conditions released. The relatively lowest N uptake shows the black earth, also in comparison of the three C levels, although there is the largest difference between the C levels.

There seems to be a greater stability of OM in the soil with a high clay content. The smaller differences shown by low C levels between open field and greenhouse conditions may be caused by the fact, that in open field N from "other sources" (immission e.g.) is effective. Under these conditions the other sources of N amount to about 50 kg/ha*a.

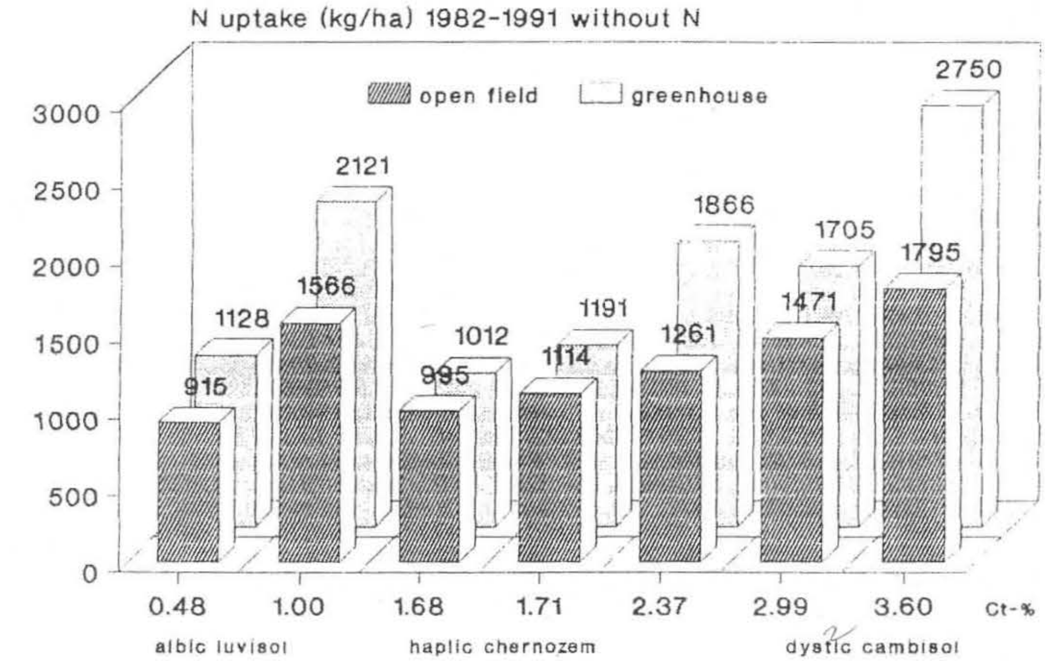
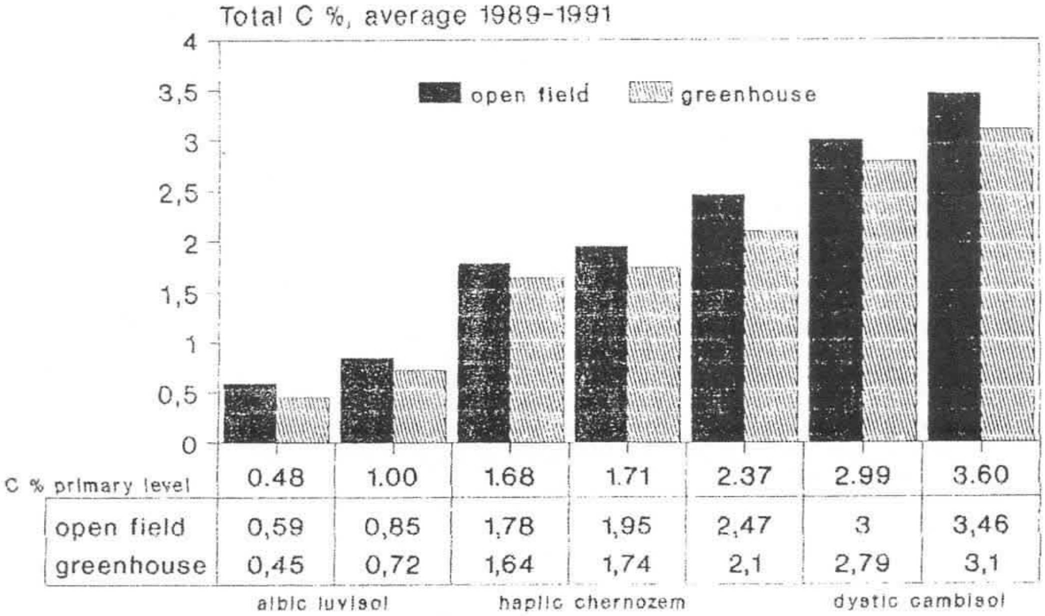


Fig. 1: N uptake of plants in pot experiments under open field and greenhouse conditions depending on C and soil type

The conversion of results from pot experiments to kg/ha is difficult and should be used in these cases only for orientation. However a comparison of corresponding results of field experiments, also in Lauchstädt, shows results of comparable order. In pot experiments under open field conditions, N uptake after 10 years amounted to 1261 kg/ha, in field experiments of the same starting level after 12 years resulted in 1240 kg/ha.

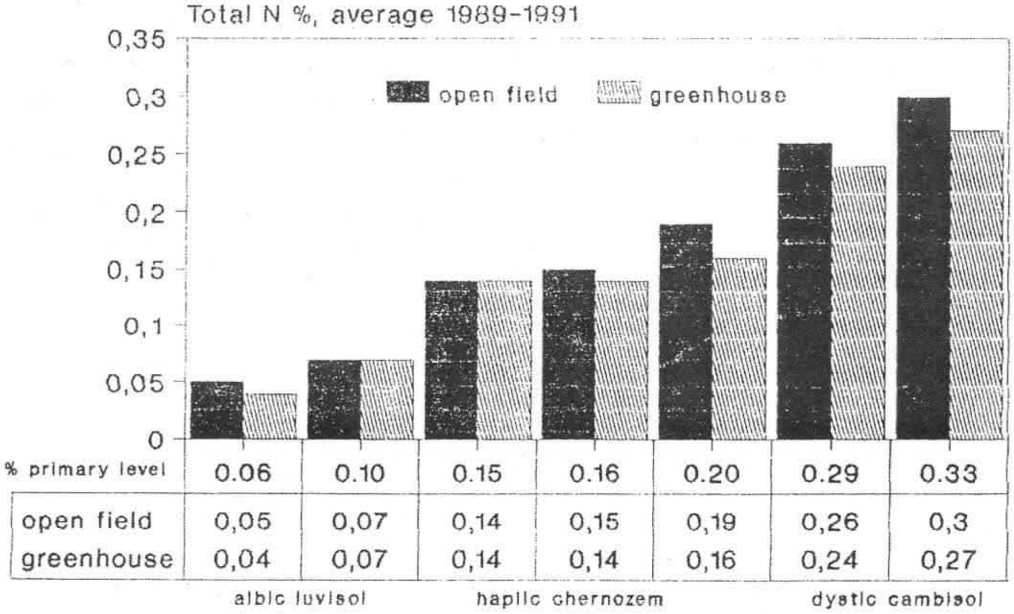
Differences between greenhouse and open field also became clear by comparison of the total C and total N content (Fig. 2 and 3). In the greenhouse the total C was in all cases lower than under open field conditions, in which the largest differences occured at the highest starting levels of each site. On an average of all treatments there was a significant difference of 0.27 % total C and 0.016 % total N.

A comparison of starting levels from 1989-1991 shows by treatment with a low starting level partially increasing C content in open field, while in the greenhouse, with one exception, all C values decreased.



C % primary level	0.48	1.00	1.68	1.71	2.37	2.99	3.60
open field	0,59	0,85	1,78	1,95	2,47	3	3,46
greenhouse	0,45	0,72	1,64	1,74	2,1	2,79	3,1
	albic luvisol		haplic chernozem			dystic cambisol	

Fig. 2: Tolal C content in soil after 10 years durationin pot experiments depending on soil type and primary level



% primary level	0.06	0.10	0.15	0.16	0.20	0.29	0.33
open field	0,05	0,07	0,14	0,15	0,19	0,26	0,3
greenhouse	0,04	0,07	0,14	0,14	0,16	0,24	0,27
	albic luvisol		haplic chernozem			dystic cambisol	

Fig. 3: Total N content in soil after 10 years duration in pot experiments depending on soil type and primary level

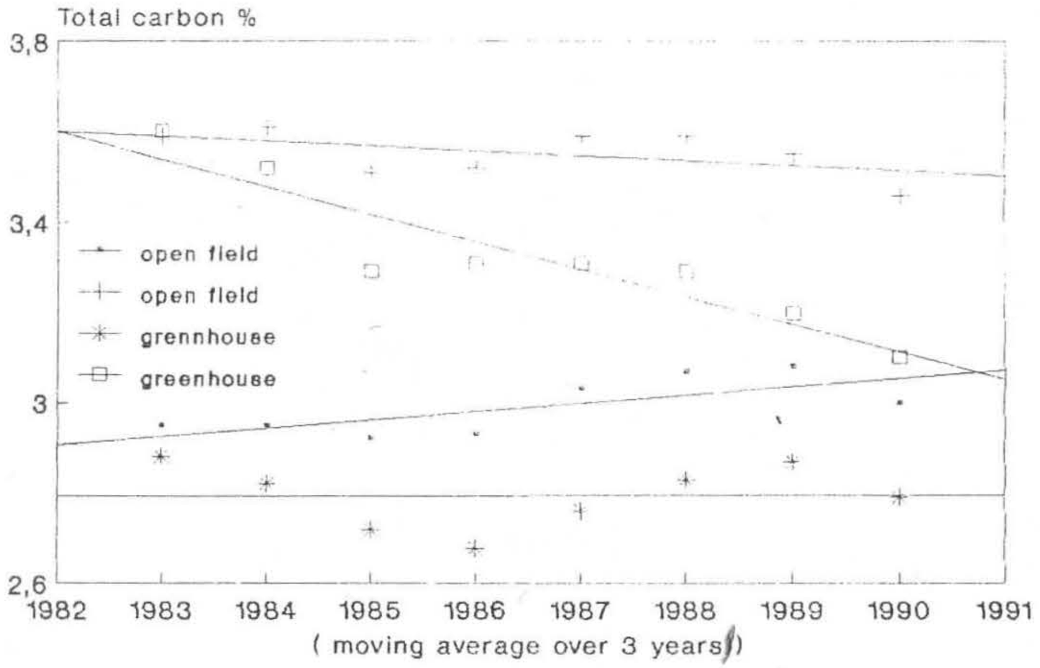


Fig. 4: Total carbon content in a 10 year pot experiment with dystic cambisol

The greatest decrease occured in line with expectations by the dystic cambisol with the highest content of decomposable C, the highest N uptake and also the largest difference in N content. Fig. 4 shows for instance the total C in dystic cambisol over 10 years. High starting levels lead to a small decrease in open field conditions, yet a large decrease in the greenhouse experiments. Low starting level in open field leads to an increase, but in the greenhouse there is no change. On average, of all soil types and C levels, the content under open field conditions remains unchanged, while in the greenhouse the content decreases (fig.5).
The increase of C content in some treatments might be caused by a greater root growth in pot experiments. Contrary to C content, the N content decreased in all treatments during the 10 years without exception, mostly in the greenhouse. This fact caused an enlargment of C/N ratios.

4. DISCUSSION AND CONCLUSIONS

In long term field experiments a steady state in C and N content appears after many decades by using same cultivation methods. Changed management also causes a changing OM content. Direction and duration of these changes depend on the starting level. Same managements show that with a high starting level of OM the level decreases, and increases with a low starting level (KÖRSCHENS,1991). In case of these pot experiments not only was the management compared to the starting conditions (crop rotation, fertilization) changed, but also climatic and weather conditions.

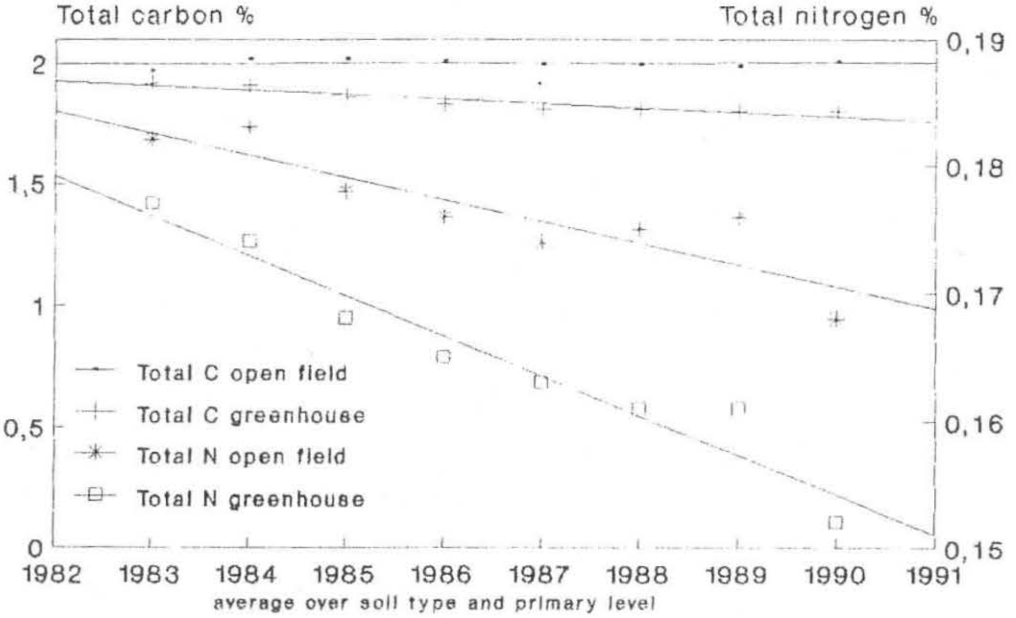


Fig. 5: Total carbon and nitrogen content in soil after 10 years duration in pot experiments (moving average over 3 years)

The treatments consequently react differently. In the greenhouse under homogeneous moisture and high temperature conditions the processes of mineralisation run more intensively. Due to this more OM is decomposed and more N is released. Under open field conditions mineralisation occurs slowly and relatively more OM from roots and harvest residues accumulated. Therefore at a low starting level the C content increases, paticularly due to N from other sources that influences the plant growth, but not under greenhouse conditions.

The larger decrease of N in comparison to C results from the fact, that decomposable OM has a closer C/N ratio to the inert part of OM, and accordingly C/N ratio in this experiment has been enlarged.

It will be possible, to calculate influence of changing climatic conditions on the humus content in soil by further precision of these connections.

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